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TECHNICAL OPERATING REPORT

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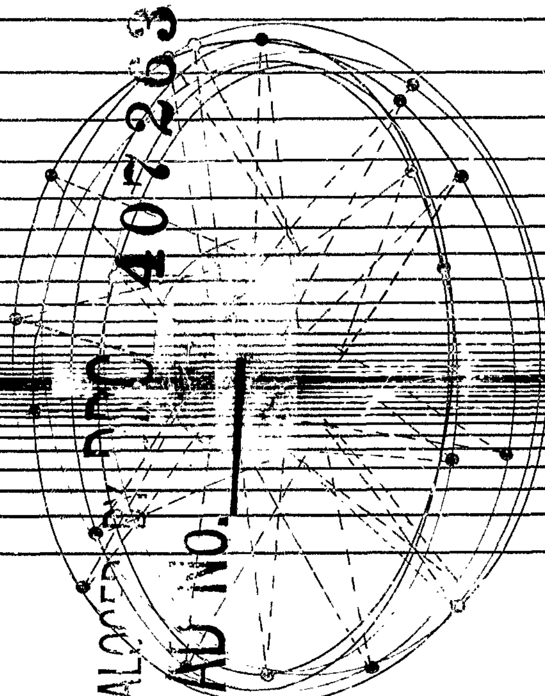

MILESTONE 4
PROGRAM 823 TRACKING AND COMMANDING
OPERATIONAL COMPUTER PROGRAM DESIGN SPECIFICATION
VOLUME I

PREPARED FOR:

AIR FORCE SPACE SYSTEMS DIVISION
AIR FORCE SYSTEMS COMMAND
UNITED STATES AIR FORCE
INGLEWOOD, CALIFORNIA

B/A I TO D/C AF04 (695) - 177

PHILCO
A SUBSIDIARY OF Ford Motor Company,
WESTERN DEVELOPMENT LABORATORIES
PALO ALTO, CALIFORNIA

WDL-TR2101
Volume 1

TECHNICAL OPERATING REPORT

MILESTONE 4
PROGRAM 823 TRACKING AND COMMANDING
OPERATIONAL COMPUTER PROGRAM DESIGN SPECIFICATION
(VOLUME 1)

Prepared by

PHILCO CORPORATION
Western Development Laboratories
Palo Alto, California

S/A 1 to D/C AF04(695)-177
AFSSD Exhibit 61-47

Prepared for

SPACE SYSTEMS DIVISION
AIR FORCE SYSTEMS COMMAND
UNITED STATES AIR FORCE
Inglewood, California

ABSTRACT

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MILESTONE 4 - PROGRAM 823 TRACKING Volume 2-Secret
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DESIGN SPECIFICATION
14 June 1963 S/A 1 to D/C AF04(695)-177

This Technical Operating Report on Program 823 Tracking and Commanding Operational Computer Programs is presented in two volumes.

These volumes present the design specifications for the Program 823 Command Module and the Paper Tape Command and Tracking Program for IOS.

THIS UNCLASSIFIED ABSTRACT IS DESIGNED FOR RETENTION IN A STANDARD 3-BY-5 CARD-SIZE FILE, IF DESIRED. WHERE THE ABSTRACT COVERS MORE THAN ONE SIDE OF THE CARD, THE ENTIRE RECTANGLE MAY BE CUT OUT AND FOLDED AT THE DOTTED CENTER LINE. (IF THE ABSTRACT IS CLASSIFIED, HOWEVER, IT MUST NOT BE REMOVED FROM THE DOCUMENT IN WHICH IT IS INCLUDED.)

FOREWORD

This Technical Operating Report has been prepared under S/A1 to Contract AF04(695)-177 and is submitted in accordance with Attachment 1 of Exhibit "A" to that contract, and Paragraph V-4 of AFSSD Exhibit 61-47. This report has been prepared by the Real-Time Programming Section of the Philco WDL Mathematical Analysis Department.

TABLE OF CONTENTS

LIST OF ILLUSTRATIONS

SECTION 1

INTRODUCTION

This document is the design specification for the Program 823 specific Tracking and Commanding (T&C) operational computer programs. There is a special commanding module and a special paper tape program associated with the Program 823 T&C Operational Computer Programs.

The special Program 823 Commanding module is an additional commanding capability to the Multiple Satellite Augmentation Computer Programs (MSAP). The completed Program 823 T&C Commanding Module will be delivered as a part of the modified MSAP Master Library Tape.

The special T&C Paper Tape Program is designed to support Program 823 satellites during an interim period at the Indian Ocean Tracking Station (IOS)when the communication with the Satellite Test Center is via a teletype link.

SECTION 2

PROGRAM 823 COMMAND MODULE

2.1 GENERAL

The Program 823 Vehicle System uses a special digital manual commanding scheme. The explicit commanding scheme will be described in a subsequent classified Milestone document, Volume 2 of this document. This section describes the routine (PDMA) which when combined with some of the existing MSAP T&C routines will form the Program 823 Commanding Module. PDMA will be a second digital manual commanding routine in the MSAP commanding subprogram (POCOM).

PDMA controls Program 823 Commanding. In this mode, a single digital command is selected and transmitted. PDMA forms the command selected by the SOC, checks whether further operator action is necessary before the command can be transmitted, formats the command, enables Interrupt 10, and checks and reports the transmission of the command.

Each Program 823 vehicle has two command receivers, each with its own command decoder. Each decoder has a unique address. PDMA selects the proper address to be sent. This is done by sensing the state of the Command Mode Buttons on the SOC. If Digital Manual is selected the address of encoder 1 is transmitted; if Auto Computer is selected, the address of encoder 2 is transmitted.

Program 823 has a small set of commands called inhibited commands. It is desirable that certain precautions be taken before these commands are transmitted. This is accomplished by requiring additional operator actions before these commands are permitted to be transmitted.

2.2 OPERATION

After either the Digital Manual or Auto Computer Command Mode has been selected on the SOC, the command number inserted at the SOC is examined. The command is checked for legality (from 1 to 62), including a check to determine if this command is to be inhibited.

The Transmit Command Button on the SOC is examined. If the Transmit button has not been pushed, control is returned to PCMS, the Command Control Routine. When the Transmit button has been pushed, PDMA selects the correct address, inserts a sync bit, formats the command for use by the Interrupt 10 Routine (PRT10), and energizes the Command Logic Equipment (CLE) so that it will interrupt the computer. When the command transmission has been finished, either on an echo check error or when the entire command has been sent, PDMA checks the conditions of transmission and sets the correct indicators so that the Report and Record subroutine (PRAR) provides the correct information for STC, the history tape, and the printer. PDMA reinitializes itself to begin this entire process again.

If an echo check error has occurred, PDMA lights the Command Error light on the SOC. PDMA permits no command transmission until the operator has pushed the Error Override Button. PDMA then turns out the Command Error light and, after a 30-second delay, permits normal commanding to resume.

If an illegal command (0 or 63 through 99) is selected, PDMA lights the Improper Command light and does not permit command transmission. PDMA de-energizes the light and resumes normal operation when a legal command is selected on the SOC.

If an inhibited command is selected on the SOC, PDMA lights the Improper Command light and does not permit command transmission. PDMA de-energizes the light and resumes normal operation if a non-inhibited command is selected. If the operator pushes the Reject Clear Button (labeled Count Clear), PDMA de-energizes the light and permits normal transmission of the inhibited command when the Transmit button is pushed.

2.3 GENERAL COMMAND AND TRACKING INFORMATION

During a pre-pass period, the special Program 823 commanding message is transmitted from STC to site. The pre-pass program verifies all the data unit checksums and the message checksum and sends the entire message back to STC. When the Bird Buffer program verifies that the message is the exact message that was sent, the Bird Buffer sends an OK to the site computer. Then the site pre-pass program writes the message on the pre-pass tape. All commanding messages used on site must therefore be sent and verified only by this transmission-return transmission method. Therefore, no provisions are made for manual insertion of command data into the system at site.

The command numbers and command words can be printed at the operator's discretion during pre-pass operations. During the pre-acquisition period just prior to the beginning of the real-time cyclic loop, the command information is loaded into core memory so that it can be used by the pass program. At this time, only the command numbers are printed.

The pointing data sent to the site during pre-pass periods on one vehicle must have a constant interval between points. This interval must be between 1 and 64 seconds. This interval is expressed as 2^N, where N must be between 0 and 6 inclusive.

The Tracking Data Selection message sent from STC to site during the pre-acquisition period specifies the report rate of tracking message as 2^N. N must be between 1 and 6 inclusive, corresponding to once every 2 seconds to once every 64 seconds.

Text messages may be sent to and from STC and site at any time at the operator's discretion. Any necessary operational information on commanding can be exchanged by this method.

The program usually cycling in the T&C computer is the T&C pre-pass program. On schedule or by operator intervention, the pre-pass program reads in and gives control to the pre-acquisition routine. The pre-acquisition routine rewinds all the tapes to be used as history tapes, puts a header on these tapes describing the next pass, and reads in the pass cycling loop. Each entry to the pass program is treated as a unique event, and a unique history tape is produced after every entry into the pass program. In case an 823 pass program is interrupted to track another vehicle, the re-entry (to begin tracking the 823 vehicle again) is treated as a unique event and a completely new history tape is written.

SECTION 3

PAPER TAPE COMMAND AND TRACKING PROGRAM FOR IOS

3.1 GENERAL

The MSAP Command and Tracking program will be modified to support Program 823 Vehicle at the Indian Ocean Tracking Station (IOS) during the period when communications with STC are via a teletype link.

Two programs will be involved. The real-time (pass) program and the non-real-time program to convert a paper tape containing pre-pass pointing data to a format that can be used by the pass program during real-time operations. The pass program will contain all information necessary to completely handle all Program 823 Commanding, obviating the necessity for command information during prepass. A pass program will be furnished for each Program 823 vehicle.

Prior to a pass, pointing data is generated at STC in a paper tape format for teletype transmission to IOS. The paper tape received at IOS is read into the computer, converted to a 160-A format, and stored on magnetic tape. When the pass program is started, the pointing data is read from magnetic tape into core memory. The pass program punches a visual header and a special header for an STC CDC-1604 computer. At lock-on, the pass program begins punching track reports. The pass program continues to punch messages until fade. A special end code is then punched on the pass tape. The tracking paper tape can then (or as soon as enough leader has been punched) be placed into the teletype machine for transmission to STC.

3.2 POINTING DATA PAPER TAPE CONVERTER (PDPTC)

The PDPTC will read the tape from STC, detect errors, and, when all data is error-free, prepare a magnetic tape for the real-time program. Since a relatively high rate of errors is expected, the pointing data tape will be transmitted to IOS twice, consecutively. Subsequent retransmission may also be necessary to get an error-free block of pointing data.

The pointing data tape should contain data for only one pass. Each message must contain 17 sets of data points with a maximum of 75 messages per tape. The tape should have a visual header (only for the operator), a Pre-Pass Coming message, Pointing Data messages, a Pre-Pass Finished message, and 15 special stop codes (teletype code 35). There should be 5 blanks between each message.

The 5-bit teletype consists of 4 data bits and a parity bit. Three consecutive characters make up a 12-bit 160-A word.

PDPTC reads in the first message off the tape. If the message is not a correct Pre-Pass coming message or if the site number in the message is incorrect, PDPTC prints this fact and halts. The operator should verify that this tape is for this site and that the first message is a Pre-Pass Coming message. PDPTC goes on to look at the pointing data if the operator sets the computer to RUN after he has replaced the tape back into the reader.

PDPTC reads in one pointing message at a time. The messages are counted and stored consecutively in a message buffer area.

Each teletype character is checked for correct parity and each complete message is checked for a correct checksum. If one of the above checks fails, PDPTC stores the message number of the message that is in error. Spaces are left in the message buffer and processing proceeds on the next data message.

After PDPTC detects a Pre-Pass Finished message or 5 stop codes (code 35), PDPTC prints the status of the pointing data that has been read in and halts. At the end of each tape, the program will output to the printer the total number of messages received and the number of the messages which are in error. The printer will indicate if no errors exist in the pointing tape. If errors exist, the operator, may place the duplicate paper tape in the reader and set the computer to RUN. PDPTC reads this paper tape looking for the messages that have not previously been processed (because of an error). When PDPTC finds a good message, it processes the message and inserts the data into the message buffer area. This process is repeatable for any number of duplicate tapes until an error-free sequence of pointing data is obtained.

If the number of messages received on the first tape and the second tape are not identical, the entire process must be restarted with new tapes from STC. There is no recovery from this condition.

If time is limited or if repeated failures on one message has led the operator to believe that the original STC tape is not good, the operator has the option of making pre-pass record which contains data from the consecutive message blocks up to the one which was in error. Subsequent blocks cannot be used.

After an error-free pointing sequence has been obtained or the operator has exercised the option to proceed, the pre-pass tape is written. The pass program expects pointing data intervals in the range of 1 point per second to 1 point per 64 seconds. If the points are received at an interval greater than 64 seconds, PDPTC interpolates the data to 1 point per 64 seconds. The PDPTC writes the pointing record on Tape Drives 2 and 3. This record also contains information needed by the pass program concerning vehicle number, revolution number, date, rise time, etc. This information, the time, azimuth, elevation, and range of all data received is printed.

Certainty can not be achieved as to when a message starts or stops on the paper tape. Spurious bits may be punched in the expected 5 blanks between messages, bits may be dropped in the 3 header characters (3-37 in teletype, 7777 in 160-A words), or whole frames may be omitted. The method described below is being used to detect the start of new messages.

When two consecutive blank frames are detected, PDPTC begins searching for 2 consecutive non-blank frames. When the 2 non-blank frames have been detected, a search begins for two consecutive non-blank frames that are 37's (or 37's with one bit missing). When these two conditions are met, a message is considered to have been detected. The message is then processed normally.

Under all but the worse transmission conditions, this procedure will keep the message count correct even though frames of data have been dropped in the process of transmission. However, bad noise burst can cause mistakes in the message count. Comparison of the number of messages received on a tape against the number received on another tape will detect this condition. If the bad comparison occurs on the first and second tapes, new tapes must be sent from STC. If the number on a subsequent tape does not compare with the number on previous tapes, no information from that tape is processed.

3.3 823 PAPER TAPE COMMAND AND TRACKING REAL-TIME PROGRAM (POCATA)

POCATA is a modified POCAT. The basic POCAT contains only the Program 823 command module, the print module, the history module, the track module of POCAT and a paper tape output module. POCATA punches a track message containing the tracking information from one antenna at maximum rate of one report every four seconds. Command messages are printed on the site printer and relayed verbally over the telephone lines. The history tape is the same format as in MSAP.

The Pre-Acquisition Subprogram (PPRE) is omitted. The functions that are necessary are performed by routines and subroutines added to the Real-Time Executive Subprogram (PRTE). These functions include reading in the pointing and pass identification data from a pre-pass tape. A visual header and a special tape identification are punched on paper tape in real-time for a transmission to STC over teletype lines.

The pre-pass pointing data magnetic tape is prepared by a non-real-time program described in Section 2.

The Real-Time STC Communication Subprogram (PCC) is omitted. The input to the real-time program will be via a special prepass magnetic tape. The output will be only tracking data on paper tape.

The Print Subprogram (PRINT), and the History Write Routine of PRTE, are the same as in MSAP.

The Pointing Data, Interpolation, Tracking, and VTCW Report Subprogram (PITAVT) is changed to permit inserted time offset to be longer than $2047_{(10)}$ seconds. There are no other changes in PITAVT.

The Operational Command Subprogram (POCOM) is specifically for Program 823 vehicles. The Program 823 Digital Commanding Routine is called PDMA. PRARA is modified MSAP Report and Record Routine (PRAR). PRARA formats data only for the history tape and the printer.

An initializing routine (PPREA) operates when POCATA is first operated. PPREA reads in the pre-pass tape on logical Tape Drive 2. A visual header and the special paper tape tracking header is punched. The vehicle number, revolution number, ETA, and ETT are illuminated on the SOC console. PPREA enter the real-time cycling loop after a 1 pps interrupt is received.

If PPREA is re-entered, the above process is repeated except that the pre-pass tape is not read in again. The headers are necessary if two separate tapes are produced or if the antenna reporting rate is changed during the pass. A re-entry to restart the pass cycle is also included.

A Paper Tape Format Subroutine (PPTFR) is added to PRTEA. After PITAVT has made up a track message for STC, PPTFR is entered. PPTFR breaks the 160-A 12-bit words into 4-bit teletype words and sets correct parity (odd). Five blank characters are added to the end of the message. PPTFR then sets a punch message gate.

A Paper Tape Punch Subroutine (PPTP) is added to PRTEA. After the punch message gate is set, PPTP is entered on every 20 PPS interrupt. PPTP punches one character per entry. When the entire message including the five blanks are punched, PPTP clears the message punch gate. A jump switch setting will stop punching after a message is complete.

The typewriter input options of PTRE are deleted. A stop switch option replaces the time offset function. If it is desired to set a pointing data time offset, the operator sets Stop Switch 2. When the computer halts, the operator inserts manually in the A-register the desired time offset (in octal). The quantity inserted is minutes between 1 and $720_{(10)}$ ($1320_{(8)}$). If a negative offset is desired, Bit 11 should be set ($\pm$ 720 minutes gives a range of $\pm$ 12 hours). When the operator sets the computer to run, the inserted offset and appropriate indicators are set for use by PITAVT. PPREA is entered to reinitiate the pass cycle.

The tracking data reporting rate may be changed also by A-register entry. After Stop Switch 4 is set, the computer halts with the present reporting rate (power of 2 seconds), in the A-register. Then, the operator clears the A-register and inserts the octal power of 2 seconds which gives the reporting rate desired. After restarting, the inserted reporting rate is compared with the old rate. If the rates differ, PPREA is re-entered to punch new headers using the new rate. PPREA reinitiates the pass cycle. The fastest reporting rate is once every 4 seconds. The slowest rate is once every 64 seconds. All punching can be suppressed by means of a jump switch.

The operator may also use this option to have new headers punched without disturbing the present reporting rate. If the operator only sets Bit 11 in the A-register, PPREA is re-entered to punch new headers. A tracking message reporting one antenna contains 15 160-A 12-bit words or 45 4-bit (plus a parity bit) teletype characters. With the 5 blanks, the punch rate is 50 frames every 4 seconds. At a report of every 4 seconds, the computer outputs 750 characters per minute. This is somewhat faster than the 100 wpm teletype which is rated at 600 characters per minute. At any other reporting rate, the teletype inputs paper tape faster than the computer punches it. Before a new header is punched, 15 stop codes (35's) and 10 inches of blank tape are punched. At Fade, 15 stop codes are also punched.

A roll of paper tape lasts approximately 6.5 hours at the maximum reporting rate. Since the program has no way of sensing the end of a roll of paper tape, provision is made for the operator to manually set a jump switch to stop punching when he wishes to change rolls. After a new roll has been inserted, the operator should use the stop switch option to punch new headers.

3.4 FORMATS

The change of format from 160-A 12-bit words to 4-bit (plus a parity) teletype characters proceeds as follows:

a. <u>160-A Word</u>

B_{11}	B_{10}	B_9	B_8	B_7	B_6	B_5	B_4	B_3	B_2	B_1	B_0

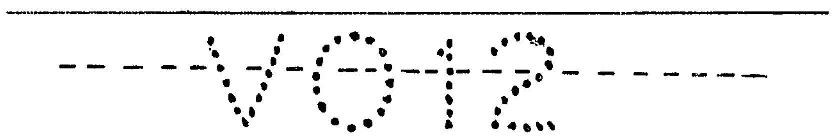
where: B_x is bit number x. Bit 11 is the most significant bit and bit 0 is the least significant bit.

b. <u>Teletype Equivalent</u>

B_{11}	B_{10}	B_9	B_8	P
B_7	B_6	B_5	B_4	P
B_3	B_2	B_1	B_0	P

where: P is the odd parity bit.

The visual header generated by the pass program is punched so that it can be read by the computer operator as he is looking down on the tape as it is output from the punch. See example, V012:



The information on the visual header includes vehicle number, revolution number, site, date, and time of punching.

c. Special Header

	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	. LS bit
.	V_{12}	V_8	V_4	V_0	S_2	I_4	I_0	F_2	B	B	B	Y_4	Y_0	M_2	D_4	D_0	R_{12}	R_8	R_4	R_0	K	.
.	V_{13}	V_9	V_5	V_1	S_3	I_5	I_1	F_3	B	B	B	Y_5	Y_1	M_3	D_5	D_1	R_{13}	R_9	R_5	R_1	B	.
.	V_{14}	V_{10}	V_6	V_2	S_4	S_0	I_2	F_4	F_0	B	B	B	Y_2	M_4	M_0	D_2	R_{14}	R_{10}	R_6	R_2	B	.
.	V_{15}	V_{11}	V_7	V_3	S_5	S_1	I_3	F_5	F_1	B	B	B	Y_3	M_5	M_1	D_3	R_{15}	R_{11}	R_7	R_3	B	. MS bit

where:

	B	=	Blank
	P	=	Odd parity
V_{15} -	V_0	=	Vehicle number, 4-bit BCD
S_5 -	S_0	=	Station number
I_5 -	I_0	=	Antenna identification
F_5 -	F_0	=	Reporting rate (power of 2)
Y_5 -	Y_0	=	Current year minus 1960
M_5 -	M_0	=	Month
D_5 -	D_0	=	Day
R_{15} -	R_0	=	Revolution number, 4-bit BCD
	K	=	AM/PM indicator: 0 = AM, 1 = PM
	.	=	Always punched

Bit 0 is the least significant bit.

NOTE: This is a representation of the tape as seen by the computer operator as he is looking down on the tape being punched or read.

d. Tracking Report Message Format

Word 1	7777	Header
2	SS14	S = Site, 14 = Message type
3	1416	14 = Message type, 16 = Word count-1
4	TT	
5	TTTT	System time
6	CCCC	Bit 11 = 1, Lock-on
		Bit 10 = 1, Active track
		Bit 9 - 6 = Antenna identification
		Bit 5 - 0 = 0, No second antenna

7	AAAA)	Azimuth, in fractions of a revolution, left unjustified
8	AAAA)	
9	EEEE)	Elevation, in fractions of a revolution, left unjustified
10	EEEE)	
11	0)	Not used
12	0)	
13	RRRR)	Range rate
14	RRRR)	
15	CKSM	Checksum

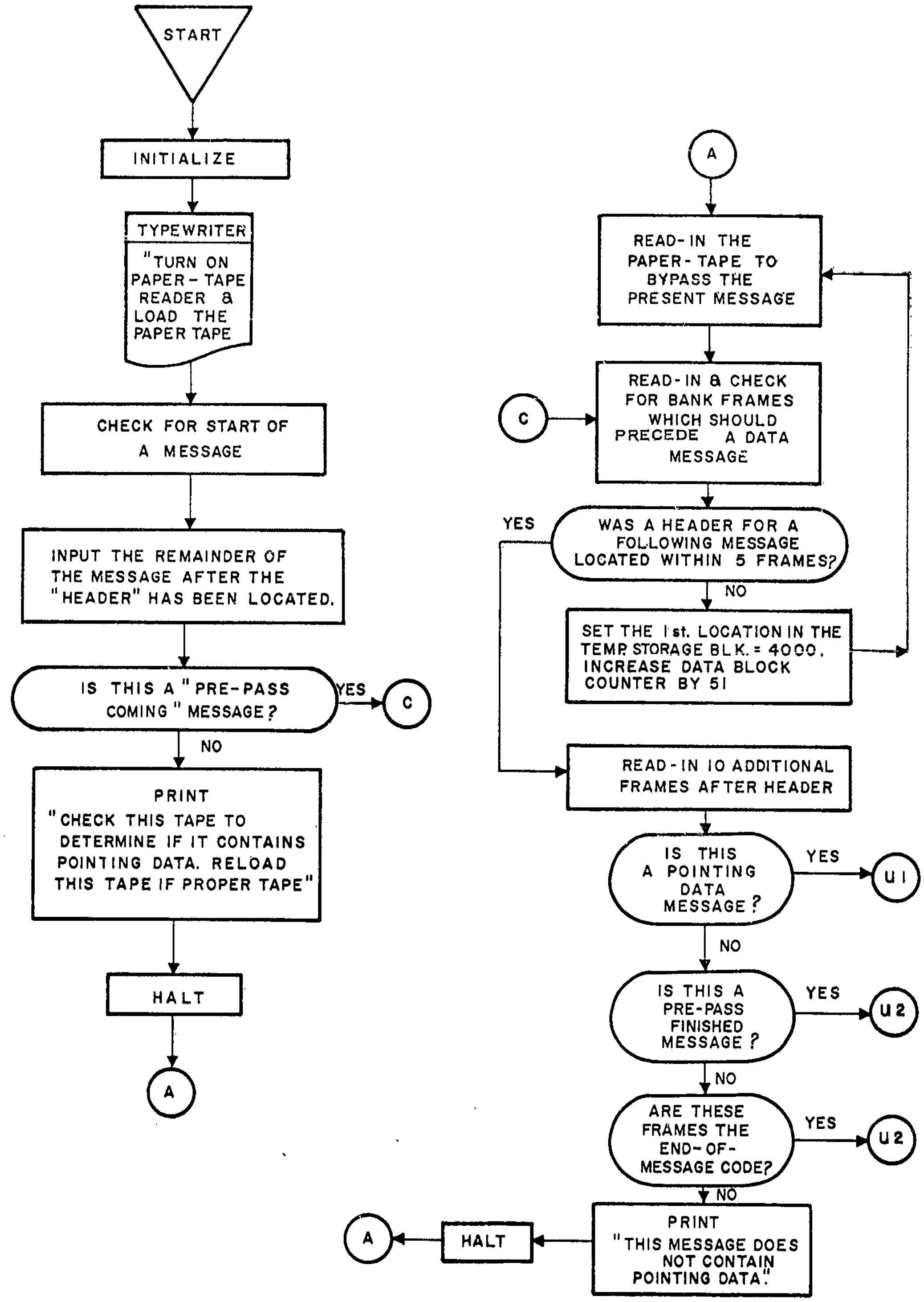


Fig. 3-1 Pointing Data Pre-Pass Paper Tape Subroutine (Sheet 1 of 4)

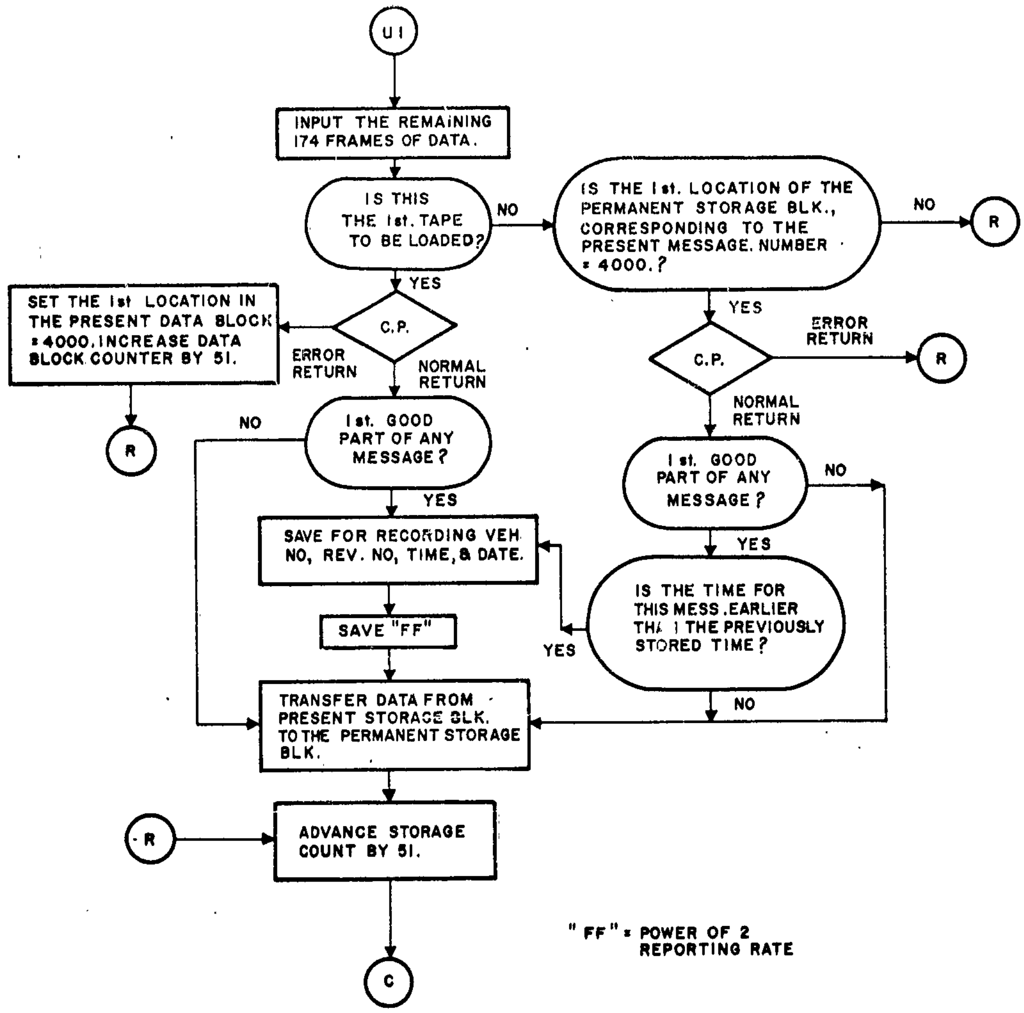


Fig. 3-2 Pointing Data Pre-Pass Paper Tape Subroutine (Sheet 2 of 4)

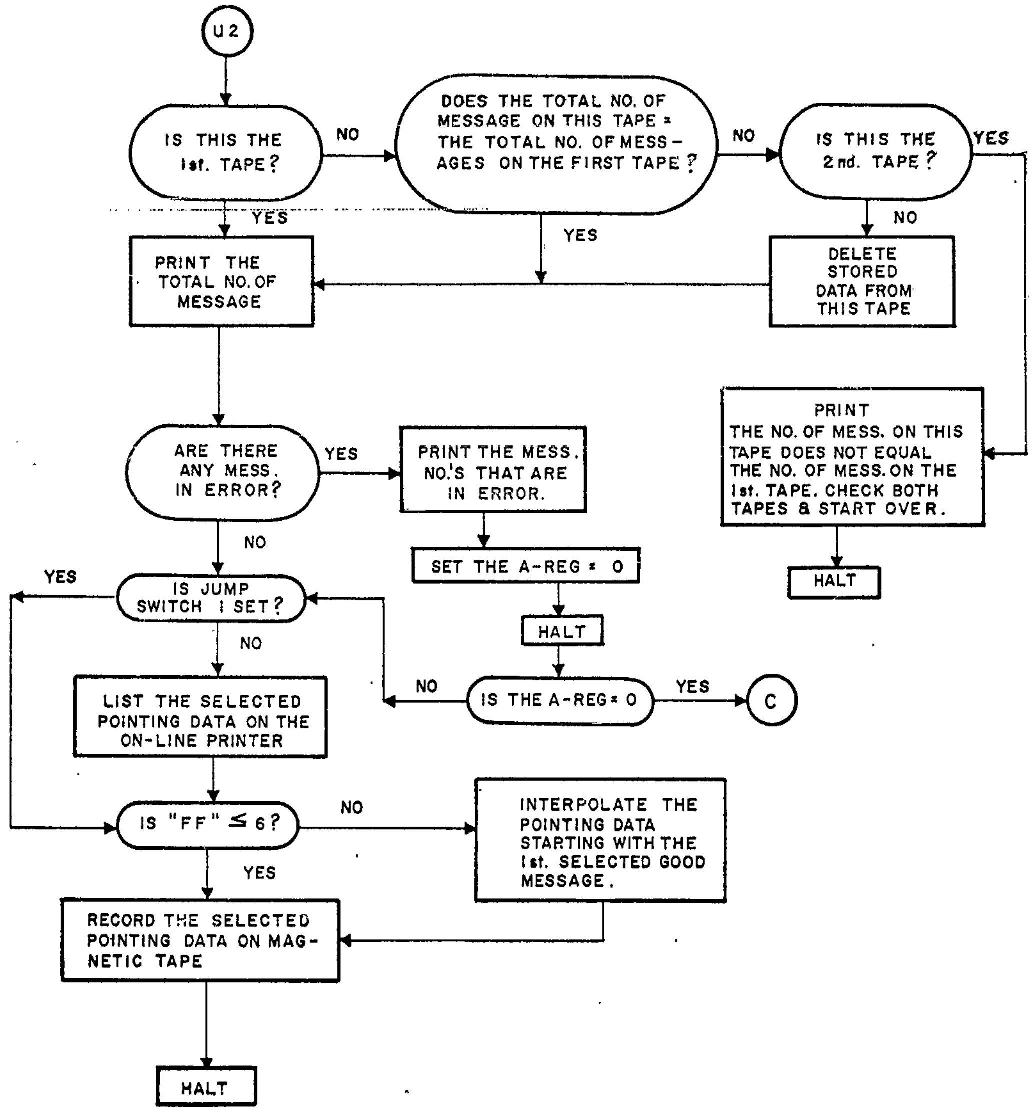


Fig. 3-3 Pointing Data Pre-Pass Paper Tape Subroutine (Sheet 3 of 4)

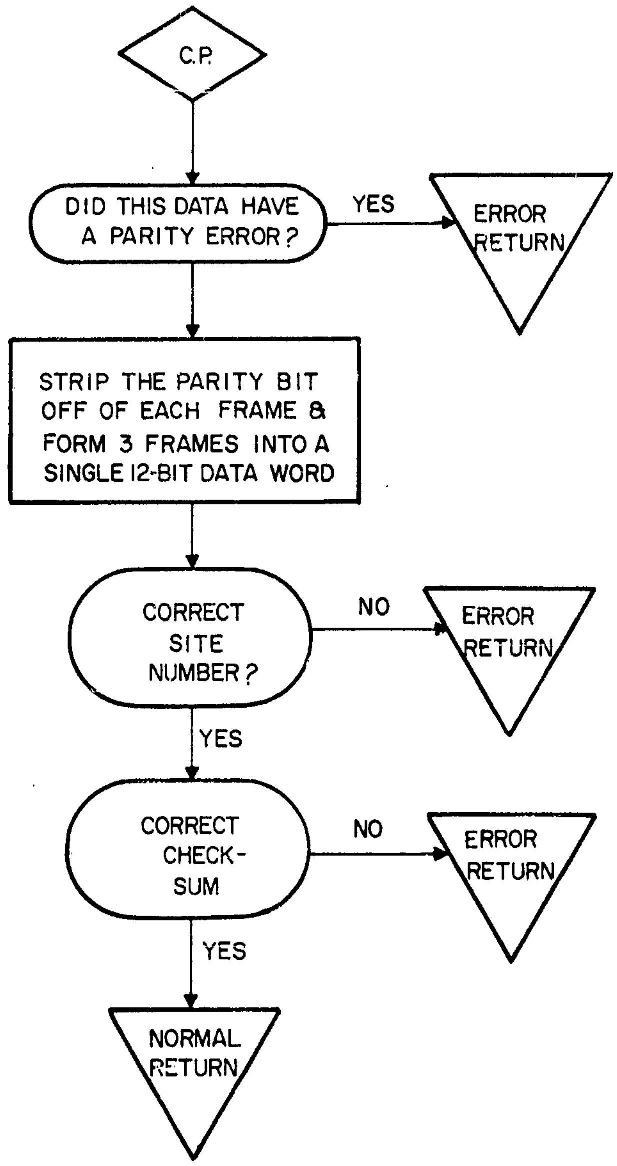
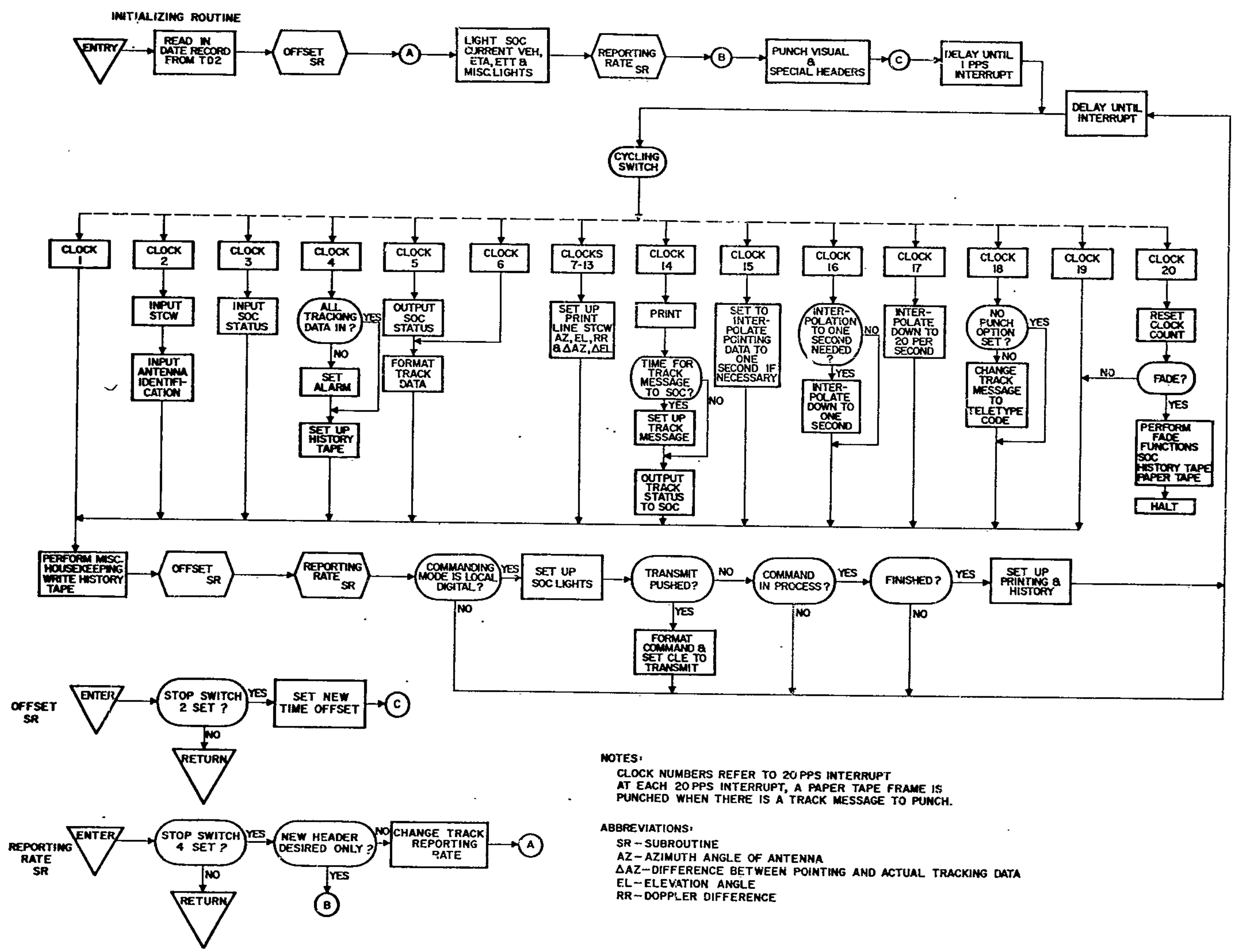


Fig. 3-4 Pointing Data Pre-Pass Paper Tape Subroutine (Sheet 4 of 4)



NOTES:
CLOCK NUMBERS REFER TO 20 PPS INTERRUPT
AT EACH 20 PPS INTERRUPT, A PAPER TAPE FRAME IS PUNCHED WHEN THERE IS A TRACK MESSAGE TO PUNCH.

ABBREVIATIONS:
SR – SUBROUTINE
AZ – AZIMUTH ANGLE OF ANTENNA
ΔAZ – DIFFERENCE BETWEEN POINTING AND ACTUAL TRACKING DATA
EL – ELEVATION ANGLE
RR – DOPPLER DIFFERENCE

Fig. 3-5 Functional Flowchart for Paper Tape Command and Tracking Pass Program for IOS

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